REMARKS

Claims 1-23 are pending in the present Application. Claims 1, 14, and 18-19 have been amended, leaving claims 1-23 for consideration upon entry of the present submission. No new matter has been introduced by way of this amendment.

Reconsideration and allowance of the claims are respectfully requested in view of the above amendments and the following remarks.

Claim Amendments

Claim 18 has been amended to correct a typographical error.

Each of independent claims 1, 14, and 19 has been amended to better define the invention. In particular, the phrase "without adsorption to a template" has been added to each claim. Support for these amendments can be found at least at Examples 2-6, and throughout the specification as filed. Examples 2-6 each provide descriptions of method for bulk separation of single wall nanotubes (SWNTs) according to type (metallic (*met-*) vs. semiconducting (*sem-*)) and diameter. None of the Examples describe, nor does the specification as a whole describe methods that use a template for adsorbing SWNT as a means to separate *met*-SWNT from *sem*-SWNT.

Further, Applicants respectfully assert that although the language "without adsorption to a template" is not present in the specification *ipsis verbis*, such is not required if the originally-filed disclosure would have conveyed to one having ordinary skill in the art that the inventor had possession of the concept of what is claimed. MPEP 2173.05(i) states that:

> Any negative limitation or exclusionary proviso must have basis in the original disclosure. *** Note that a lack of literal basis in the specification for a negative limitation may not be sufficient to establish a *prima facie* case for lack of descriptive support. *Ex parte Parks*, 20 U.S.P.Q.2d 1234, 1236 (Bd. Pat. App. & Inter. 1193).

(Emphasis added) In *Ex parte Parks*, the Examiner had rejected the limitation "in the absence of a catalyst" because there was no literal statement in the specification to support the limitation. The Board held that "literal support does not, in and of itself, establish a *prima facie* case for lack of adequate descriptive support under the first paragraph of 35 U.S.C. 112." *Id.* The Board also held that "it is sufficient if the originally-filed disclosure would have conveyed to one having ordinary skill in the art that an appellant had possession of the concept of what is claimed." *Id.*

In footnote 3, the Board points out that "whether the requirement for an adequate written description has been met is a question of fact and, hence, driven by the exigencies of each case."

Moreover, the Board of Patent Appeals & Interferences has consistently held that the specification does not require a literal statement supporting a negative limitation. In *Ex parte Kenneth E. Starling Jr., and Brian J. Love*, 1995 WL 1696871, *2 (Bd. Pat. App. & Inter. 1995), the claim language at issue was "curable without the application of any supplemental heat." The Board held that "Although the disclosure is silent as to the use of heat, it can reasonably be said that appellants' silence would have disclosed to one of ordinary skill in the art that the dental adhesive would have been "curable in the absence of heat." *Id.*; emphasis supplied.

Here, the originally filed disclosure would have conveyed to one having ordinary skill in the art that the applicant had possession of the concept of what is claimed, in that an ordinary person skilled in the art would have understood that the invention is directed to methods of separating *met*-SWNT from *sem*-SWNT "without adsorption to a template." Note that the specification does not disclose any method of separating *met*-SWNT from *sem*-SWNT with the use of a template. None of the examples 2-6 use a template. Thus, Applicants believe that the disclosure provides clear antecedent basis for methods of separating *met*-SWNT from *sem*-SWNT "without adsorption to a template."

Claim Rejections Under 35 U.S.C. § 103(a)

Claims 1-23 stand rejected under 35 U.S.C. § 103(a), as allegedly unpatentable over United States Patent No. 6,669,918 to Schleier-Smith *et al.* ("Schleier-Smith") in view of United States Patent Nos. 6,187,823 and 6,368,569 to Haddon *et al.* ("the Haddon patents"). (Office Action dated 8/16/2006, page 2) The Applicant respectfully traverses this rejection.

For an obviousness rejection to be proper, the Examiner must meet the burden of establishing a *prima facie* case of obviousness. *In re Fine*, 5 U.S.P.Q.2d 1596, 1598 (Fed. Cir. 1988). Establishing a prima facie case of obviousness requires that all elements of the invention be disclosed in the prior art. *In Re Wilson*, 165 U.S.P.Q. 494, 496 (C.C.P.A. 1970). The Applicant asserts that a *prima facie* case of obviousness has not been established because the cited references fail to teach or suggest all limitations of Applicant's independent Claims 1, 14, and 19.

Independent claims 1, 14, and 19 are is directed to a method of separating *met*-SWNTs from *sem*-SWNTs without adsorption to a template. Schleier-Smith, on the other hand, requires use of a template in separating SWNTs. As acknowledge by the Examiner:

> Schleier-Smith et al '918 discloses suspending a population of mixed single wall nanotubes (SWNT) . . . , followed by separation steps to separate the types of SWNT, including a type of selective precipitation of met or sem SWNT, concerning deposition of nanotubes [having] a selected chirality corresponding to the chirality of either semiconduction or metallic nanotubes, on a template (column 3, lines 24-34 and column 4, lines 62-column 5, line 4).

Office Action dated 8/16/2006, page 3, emphasis added.

Schleier-Smith itself states that it is directed to "a method for bulk separation of single-walled tubular fullerenes utilizing a template for adsorbing single-walled tubular fullerenes of a predetermined chirality." (Col. 1, ll. 10-13, emphasis added) As stated in the Abstract as well as numerous time throughout Schleier-Smith, the template is exposed to a suspension of single walled tubular fullerenes of random chiralities for adsorption of single walled tubular fullerenes of the selected chirality into the openings of the template. Abstract; col. 2, ll. 17-34.

Schleier-Smith thus does not disclose or suggest any method of separating *met*-SWNTs from *sem*-SWNTs without adsorption to a template, or a method for selective extraction of *sem*-SWNTs from a mixture of *sem*-SWNTs and *met*-SWNTs without adsorption to a template. Independent Claims 1, 14 and 19 positively exclude utilizing a template for adsorbing SWNTs. For this reason at least, Schleier-Smith does not disclose or suggest all of the limitations of the present claims.

The Haddon patents fail to remedy this deficiency. Specifically, the Haddon patents fail to compensate for the deficiencies of Schleier-Smith. The Haddon patents are directed to methods for solubilizing carbon nanotubes. (Abstract) While the Haddon patents disclose the separation of single walled carbon nanotubes from impurities (e.g., metal catalysts, nanoparticles, graphite, amorphous carbon, fullerenes, and other contaminants) ('823 patent, col. 3, ll. 59-65), the Haddon patents do not disclose or suggest separation of the different types of single walled carbon nanotubes from each other according to type (metallic (*met*-) vs. semiconducting (*sem*-)) and diameter. In fact, the Haddon patents focus only on the solubilization of single walled carbon nanotubes in general, and fail to distinguish between the different types of single walled carbon nanotubes altogether.

The Haddon patents certainly do not disclose a method of separating *met*-SWNTs from *sem*-SWNTs, or a method for selective extraction of *sem*-SWNTs from a mixture of *sem*-SWNTs and

met-SWNTs, without adsorption to a template. Thus, the Haddon patents and, individually or in combination, do not disclose all of the elements of the claimed invention.

It is further believed that neither Schleier-Smith nor the Haddon patents, alone or in combination, suggest the separation methods as presently claimed. In the present application, the Applicants disclose novel method to separate SWNTs according to type (semiconducting vs. metallic) and diameter. Such separation is not based on preparation and use of a template; rather it is based on the differential redox behavior of *met-* vs. *sem*-SWNTs to the redox equilibrium. Applicant recognized that this differential redox behavior could be exploited to allow separation *met-* vs. *sem*-SWNTs using different techniques.

In one embodiment, which is specifically set forth in claims 9-13, the SWNTs can be acid functionalized. Without being held to theory, it is believed that upon exposure of SWNTs to an acid (HNO_3/H_2SO_4), these nanotubes oxidize (i.e., lose electrons, which causes them to p-dope) causing them to loose about 2 to 4 electrons per 100 carbon atoms. Such electron loss is accompanied by the strong association of equal number of counter ions (i.e. NO_3^-, SO_4^{2-}, and the like) to balance the positive charge on SWNTs. Such strong association of polar counter ions to the hydrophobic SWNT sidewalls increases the polarity of these nanotubes and renders them soluble in polar aprotic solvents such as DMF (dimethyl formamide).

Upon exposure to amines non-surfactant amines, the pH of the nanotube suspension is raised for 0 to pH 10. This decreases the H+ concentration by 10 orders of magnitude, which shifts the equilibrium, replacing electrons to the nanotubes and raises the oxidation level of the SWNT. For the *met*-SWNT, such redox jump entails a small change, which leaves a fair amount of charges still on these metallic nanotubes. On the other hand, the similar redox jump completely dedopes the sem-SWNT and brings them back to their pristine un-oxidized state. Such action results in the removal of both charges and stabilizing counter ions from the sem-SWNTs, reverting them back to their hydrophobic state, which causes them to aggregate and precipitate. On the other hand the *met*-SWNTs, since they retain some charge, remain in solution. This embodiment is disclosed at paragraph [0035] and claimed in dependant claim 9.

Figure 1 provides a pictorial representation of the interaction of various amines with SWNTs. On the left is illustrated an acid-oxidized (p-doped) SWNT with a large number of negative counter ions (red) on its surface. As explained above, it is these counter ions that render these p-doped

SWNTs soluble in polar solvents like DMF. Upon introduction of non-surfactant amines (i.e. dimethyl amine (DMA)) the *sem*-SWNTs dedope more effectively than the met-SWNTs, which causes the sem-SWNTs to precipitate in DMF, while the met-SWNTs to remain in solution. This is schematically shown in Figure 1(i) and is claimed in dependent claims 9-10.

In another embodiment, which is set forth in dependent claims 5-8, if surfactant amines (i.e., octadecyl amine (ODA)) are used instead for differential dedoping, the counter-ion free sidewalls of sem-SWNTs enable the more facile organization of the ODA monolayers as opposed to *met*-SWNTs. This is schematically shown in Figure 1(ii). The tight organization of surfactant amines onto the sidewalls of SWNTs create an "artificial micelle" that induces better solubility for *sem*-SWNTs in less polar solvents (like tetrahydrofuran (THF)) as opposed to *met*-SWNTs that can easily precipitated by a simple centrifugation, filtration or flash-column eluting step.

Figure 1.

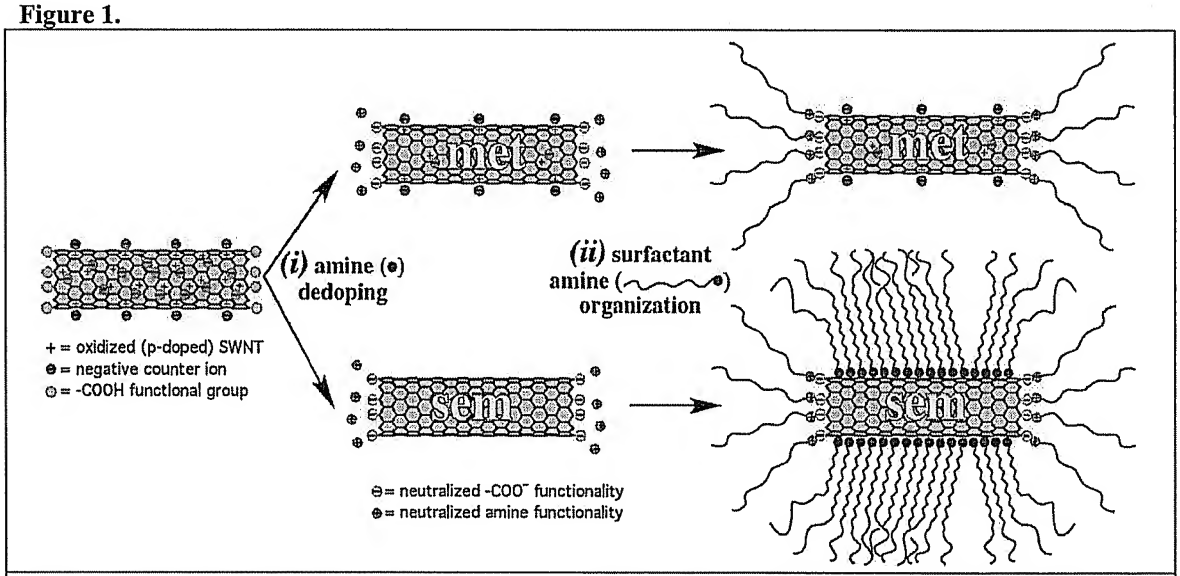

Figure 1. Schematic illustration of the *two modes* of metallic from semiconducting SWNT separation afforded by amines: *(i)* amine-assisted selective dedoping of *sem*-SWNTs that preferentially precipitates them in polar solvents (such as DMF) (claim 9), and *(ii)* surfactant amine organization onto the side-walls of dedoped *sem*-SWNTs as opposed to the doped met-SWNTs, that render them more soluble in less polar solvents (like THF) (claim 1).

A variation of this procedure is the selective extraction of non-acid functionalized SWNTs by treating them with surfactant amines (independent claim 14). Typically, the larger electron density of met-SWNTs renders them more doped, which thereby impedes the organization of surfactant amines on their side-walls as opposed to sem-SWNTs. Based on this, following SWNT treatment

with surfactant amines, extraction with low polarity solvents selectively extracts the sem-SWNT fraction of the sample.

In still another embodiment, the claimed separation relies on the selective precipitation of SWNTs according to nanotube diameter (dt) (independent claim 19). This is shown in Figure 5 of the specification. When sem-enriched SWNT fractions that have been suspended in DMF are treated with progressively larger amounts of dimethylamine, the large diameters (small RBM Raman shifts) sem-SWNTs precipitate first and then the smaller diameters (large RBM Raman shifts) precipitate last (see Fig. 9). As shown in Fig. 9, the smaller dt-SWNTs (0.9 nm) resist precipitation when compared with larger nanotubes. Progressively larger amounts of dimethylamine eventually precipitates the smaller nanotubes as well, thereby affording us to separate SWNTs by diameter.

The combination of Schleier-Smith with the Haddon patents do not teach or suggest the foregoing separations. Applicant believes that the Examiner has not established a *prima facie* case of obviousness against claims 1, 14 and 19, as well as those claims that depend therefrom. Applicant respectfully request reconsideration and withdrawal of the rejection applied to Claims 1-23 under 35 U.S.C. § 103(a) and an allowance of the claims.

It is believed that the foregoing remarks fully comply with the Office Action and that the claims herein should now be allowable to Applicant. Accordingly, reconsideration and allowance are requested.

If there are any additional charges with respect to this submission or otherwise, please charge them to Deposit Account No. 06-1130.

Respectfully submitted,

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